INVESTOR IN PEOPLE

Isis Innovation Ltd
% J A Kemp & Co
14 South Square
Gray's Inn
LONDON
WC1R 5LX

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

Examiner: 01633 813745
†**E-mail:** peter.egerton@patent.gov.uk
Switchboard: 01633 814000
Fax: 01633 814444

Your Reference: N.76897 MN
Application No: GB 9922198.8

27 January 2000

Dear Sirs

Patents Act 1977: Search Report under Section 17(5)

I enclose two copies of my search report and three copies of the citations.

Publication

I estimate that, provided you have met all formal requirements, preparations for publication of your application will be completed soon after **13 February 2001**. You will then receive a letter informing you of completion and telling you the publication number and date of publication.

Amendment/withdrawal

If you wish to file amended claims for inclusion with the published application, or to withdraw the application to prevent publication, you must do so before the preparations for publication are completed. **No reminder will be issued.** If you write to the Office less than 3 weeks before the above completion date, please mark your letter prominently: **"URGENT - PUBLICATION IMMINENT"**.

Yours faithfully

Peter Egerton

Peter Egerton
Examiner

---

†**Use of E-mail:** Please note that under patent law e-mail may be used to file correspondence only.

Application No:	GB 9922198.8	**Examiner:**	Peter Egerton
Claims searched:	1-23	**Date of search:**	26 January 2000

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): G2X (XB20X, XB21)

Int Cl (Ed.7): G03F 7/00

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	WO93/11861	(MINNESOTA MM) see Fig 1 and page 5 lines 11-19, page 13 lines 3-8 and Examples esp Example 13	1-4,7,9, 10-12,14, 20,21
X	US 4801379	(SULZER) see Figs 1& 2 and col 2 lines 29-44 and col 3 lines 18 - col 4 line 65,	1-5,7-9, 11,12,14, 17,18,20, 21
A	US 4496216	(POLAROID) see e.g Fig 10	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
N.76897A MN		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/GB00/03602	20/09/2000	20/09/1999
International Patent Classification (IPC) or national classification and IPC B01D39/16		
Applicant ISIS INNOVATION LIMITED et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 4 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
12/03/2001	14.12.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Katsoulas, K Telephone No. +49 89 2399 8613

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/GB00/03602

I. Basis of th rep rt

1. With regard to the **elem nts** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-11 as originally filed

Claims, No.:

1-21 as originally filed

Drawings, sheets:

1/3-3/3 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	6,8-10,13,15,16,19
	No:	Claims	1-5,7,11,12,14,17,18,20,21
Inventive step (IS)	Yes:	Claims	6
	No:	Claims	8-10,13,15,16,19
Industrial applicability (IA)	Yes:	Claims	1-21
	No:	Claims	

2. Citations and explanations
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

D1: US-A-4801379; D2: US-A-4923608

Ad Section V:

1. D1 discloses (cf. claim 12) a method of forming a porous filter element comprising the steps of exposing a photosensitive material (5) (eg. paint) to an interference pattern produced by monochromatic and coherent light such as laser beams (col. lines 42-44) to produce a relief surface having a plurality of discrete protuberances and depressions. According to col. 4 lines 50, 51 and fig. 2a, the depressions can extend as far as the substrate surface i.e. no saddles (4") are present. It follows that the relief photosensitive material (5) can be perforate. Although no treatment step to remove the exposed photosensitive material is explicitly mentioned in claim 1, it is considered that such a step is implied by the "subsequent development" indicated on col. 1 lines 26-30 discussing known relief surface producing mechanisms. Finally, the clause "whereby exposure through the material varies in accordance with the spatially varying intensity created by the interference" in claim 1 is considered as a direct effect of using such an irradiation method. In summary, claim 1 lacks novelty in view of the above disclosure of D1 (Art. 33(2) PCT). This conclusion extends also to dependent claims 2-5, 7, 11, 12, 14, 17, 18, 20, as well as to product claim 21.

2. For the dependent claims 8-10, 13, 15, 16 and 19 no surprising effect can be acknowledged in view of the available art (Art. 33(3) PCT).

3. The particular normalised optical wave-vectors and polarization unit vectors according to claim 6 cannot be derived nor rendered obvious by the available art.

Ad Section VIII:

1. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D1 and D2 is not mentioned in the description, nor are these documents identified therein.

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

To:
J.A. KEMP & CO.
Attn. NICHOLLS, Michael John
14 South Square
Gray's Inn
London WC1R 5LX
UNITED KINGDOM

	Date of mailing *(day/month/year)* 20/02/2001
Applicant's or agent's file reference N.76897A MN	**FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/GB 00/03602	International filing date *(day/month/year)* 20/09/2000
Applicant ISIS INNOVATION LIMITED et al.	

1. [X] The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Chantal Meyer

Form PCT/ISA/220 (July 1998)

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international publication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When? Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How? Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped),whether

(i) the claim is unchanged;

(ii) the claim is cancelled;

(iii) the claim is new;

(iv) the claim replaces one or more claims as filed;

(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."

2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."

3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."

4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international appplication is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	FOR FURTHER ACTION	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
N.76897A MN		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/GB 00/ 03602	20/09/2000	20/09/1999
Applicant		
ISIS INNOVATION LIMITED et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language,** the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 5

   [X] as suggested by the applicant.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

   [ ] None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No
GB 00/03602

A. CLASSIFICATION OF SUBJECT MAT
IPC 7 B01D39/16 B01D67/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
WPI Data, PAJ, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 801 379 A (C.EHRSAM ET AL.) 31 January 1989 (1989-01-31) the whole document	1-5
A	US 4 652 412 A (C.A.CHIULLI) 24 March 1987 (1987-03-24) column 3, line 4 - line 31; claim 1; figure 1	1
A	US 4 923 608 A (T.FLOTTMANN ET AL.) 8 May 1990 (1990-05-08) the whole document	1-21
A	US 5 256 360 A (H.LI) 26 October 1993 (1993-10-26) claim 1	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 February 2001	20/02/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Bertram, H

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
[redacted]/GB 00/03602

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 4801379	A	31-01-1989	CH	671709 A	29-09-1989
			AT	73687 T	15-04-1992
			DE	3777480 A	23-04-1992
			DK	230187 A	24-01-1988
			EP	0254103 A	27-01-1988
			FI	871954 A	24-01-1988
			JP	63031516 A	10-02-1988
			NO	872990 A	25-01-1988
US 4652412	A	24-03-1987	NONE		
US 4923608	A	08-05-1990	DE	3742770 A	29-06-1989
			DE	3887121 D	24-02-1994
			EP	0325752 A	02-08-1989
			JP	2043927 A	14-02-1990
US 5256360	A	26-10-1993	NONE		

PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 28 May 2001 (28.05.01)	
International application No. PCT/GB00/03602	**Applicant's or agent's file reference** N.76897A MN
International filing date (day/month/year) 20 September 2000 (20.09.00)	**Priority date** (day/month/year) 20 September 1999 (20.09.99)
Applicant TURBERFIELD, Andrew, Jonathan et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

12 March 2001 (12.03.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland**	Authorized officer Olivia TEFY
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
29 March 2001 (29.03.2001)

PCT

(10) International Publication Number
WO 01/21285 A1

(51) International Patent Classification[7]: B01D 39/16, 67/00

(21) International Application Number: PCT/GB00/03602

(22) International Filing Date:
20 September 2000 (20.09.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
9922198.8 20 September 1999 (20.09.1999) GB

(71) Applicant *(for all designated States except US)*: **ISIS INNOVATION LIMITED** [GB/GB]; Ewert House, Ewert Place, Summertown, Oxford OX2 7DD (GB).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **TURBERFIELD, Andrew, Jonathan** [GB/GB]; 29 Derwent Avenue, Headington, Oxfordshire OX3 0AR (GB). **DENNING, Robert, Gordon** [GB/GB]; 26 The Row, Tootbaldon, Oxfordshire OX44 9NE (GB).

(74) Agents: **NICHOLLS, Michael, John** et al.; J.A. Kemp & Co., 14 South Square, Gray's Inn, London WC1R 5LX (GB).

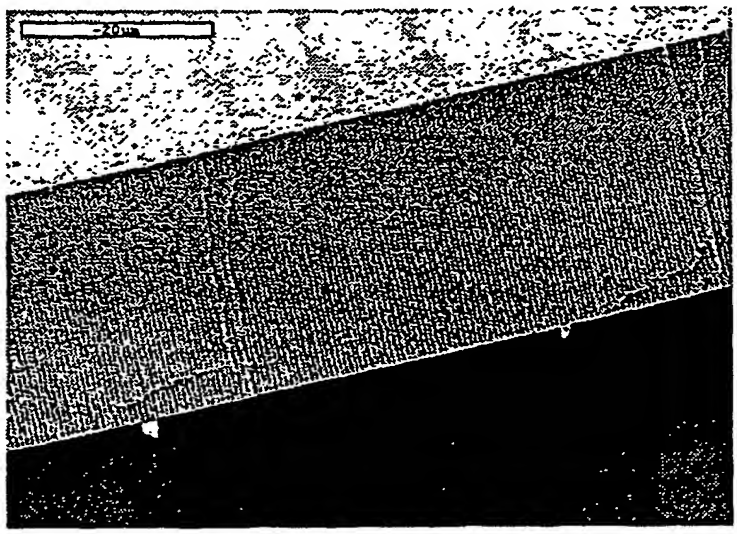
(81) Designated States *(national)*: JP, US.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published:
— *With international search report.*
— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: POROUS FILTER ELEMENT AND METHOD OF FABRICATION THEREOF



(57) Abstract: A method of making a porous filter element by defining in a body of photosensitive material a pattern of varying intensity e.m. radiation (e.g. light), by creating an interference pattern in the material. After exposure to the e.m. radiation, regions of the material are selectively removed (e.g. dissolved away) in dependence upon the exposure to which they were subjected. This results in a porous element which can be used directly as a filter element, or which can be used as a lost mould to create a filter element from a different material. In that usage the voids in the resin material are filled with the material from which it is desired to make the filter, and then the resin is removed. Varying the intensity and the pattern varies the size, shape and disposition of the regions which are removed, and thus of the pores in the filter.

WO 01/21285 A1

(15) Information about Correction:
see PCT Gazette No. 36/2002 of 6 September 2002, Section II

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Porous Filter Element And Method Of Fabrication Thereof

The present invention relates to a porous filter element and in particular to a method of manufacturing such a filter element.

There are many different types of porous filter element, ranging from the relatively unsophisticated and familiar filter papers, and filters made of felt and woven materials, to more sophisticated filters formed from, for example, porous films, such as nucleopore filters and Anotech filters (made from an aluminum oxide film).

Nucleopore filters are made by bombarding a polymer film with alpha particles and then etching the regions damaged by the alpha particles to produce holes. Because the pattern of holes is random, the intensity of alpha particles has to be kept low to avoid holes running into each other. Thus the filter produced can only have a low porosity if hole uniformity is to be maintained.

The present invention is concerned with a new way of making a porous filter element, which gives close control over the shape and arrangement of the pores, and which is capable of making a filter with a highly regular and controllable array of pores over a large range of scales down to the microscopic.

In the present invention this is achieved by using a photosensitive material, such as a photosensitive resin, as the starting material, and exposing this starting material to an interference pattern of electromagnetic radiation so that different areas of the photosensitive material are exposed differently according to the variation in intensity caused by the interference. The material is then treated, e.g. using a chemical solvent, to remove selectively regions which have been exposed by an amount which is greater or less than a predetermined critical amount, this treatment leaving voids in the material. The material can then be used either directly as a filter element, or it can be used as a mould to produce a filter element, for instance by filling the voids with a material which solidifies, and then removing the original photosensitive material.

Because the array of pores is defined by the interference pattern of e.m.

radiation, e.g. u.v. light, controlling this pattern gives close control over the shape, size and disposition of the pores. Interference patterns are highly regular and so a highly regular array of pores can be created.

The interference pattern can be created as a 3-D pattern in the photosensitive material by interfering three or more coherent or partially coherent laser beams therein. The pattern can be arranged to vary only in two dimensions, with it being substantially constant in the third dimension (which may correspond to the normal to the surface of the filter), so that the result of selective removal of material is an array of constant cross-section channels extending through the material from one side of the material to the other. Alternatively, it is possible to arrange for the interference pattern to vary in the third dimension also by use of at least four interfering beams, creating a pattern of interconnecting voids in the material which varies in all three dimensions.

An alternative method for producing an interference pattern that varies in two dimensions and does not require a coherent light source is a grating interferometer, for example as described by Berger and co-workers [J. Appl. Phys. vol. 82, p.60-64 (1997)]. Alternatively, a pattern of exposure that varies in two dimensions may be created by superposition of two or more exposures that vary periodically in intensity in one dimension, but have different orientations.

For a given wavelength of e.m. radiation, the angles between the interfering beams decide, and can be used to control, the period of the interference pattern. The overall intensity of the interfering beams or the exposure time or the chemical composition of the photo resist can be changed to change the pore size by varying the amount of material which is exposed by more than the critical amount (and thus the amount which is removed in the treatment step). Thus for a fixed periodicity the pore size is continuously variable.

The relative polarization and relative intensity of the interfering beams can be varied to adjust the shape of the pores by varying the pattern of interference.

Thus this close control of pore size and shape, with absolutely regular periodicity, allows the pores to be packed very closely together and sized to make a high throughput yet fine filter without the problem of pores joining together found in a random creation process.

Of course, in practice the interference pattern may only be created in a part of the body of photosensitive material. The rest can be used as an integral support or the porous part of the body can be cut out for use as a filter element.

Depending on the nature of the photosensitive material used, it is possible that either regions which are subject to an exposure greater than a predetermined amount, or less than a predetermined amount, are removed by the treatment step. For instance, the material could be a resin in which cross-linking occurs on exposure to light, with non-cross-linked regions then being removed by using a suitable solvent, to create pores corresponding to the dark regions of the pattern.

The resin can contain a photosensitive agent which responds to the light and then causes cross-linking to occur either straightaway or on application of heat. In this way the pattern forms a "latent image" in the resin, which is developed subsequently by heating and chemical treatment.

Alternatively the photosensitive material can be one in which the exposure to light increases its solubility (either directly or via a photosensitive agent) by, for example, reducing the degree of cross-linking or by changing its polarity, in which case the pores will correspond to the light regions of the pattern.

The photosensitive material may conveniently be prepared in the form of a thin film (e.g. by spinning or spreading using a roller or blade), which is then exposed to the interference pattern.

Where the exposed and treated photosensitive material is to be used as a mould to form a filter element, the voids in the material can be filled with an inert material such as a metal, e.g. nickel, silver or gold, (which can be introduced by electrochemical or electroless deposition) or a ceramic, the photosensitive material then being removed. Where a ceramic is used, which is solidified by sintering, the sintering process is also effective to burn off the original photosensitive material.

The invention is capable of producing porous filter elements in which the pores consist of very long narrow channels through the element. For instance, the channels can have a diameter of the order of 0.1 micrometers, with a spacing of the order of 0.5 micrometers, in a filter element of thickness of the order of 30 micrometers. On the other hand, the same method is also capable of producing much

larger scale filters with regular arrays of pores over a large area.

The invention will be further described by way of non-limitative example with reference to the accompanying drawings in which:-

Figure 1 schematically illustrates the arrangement used to expose the photosensitive material;

Figure 2 schematically illustrates a first filter element according to the invention;

Figure 3 illustrates a second filter element made according to the invention;

Figure 4 is a scanning electron micrograph of a filter element of the type illustrated in Figure 2; and

Figure 5 is a scanning electron micrograph which shows the element of Figure 4 fractured; and

Figure 6 shows a simulation of an element with circular channels.

Figure 1 schematically illustrates the arrangement for exposing a body 1 of photosensitive material to a desired light pattern. As will be explained below, the body 1 of photosensitive material can be in the form of a spun film. In Figure 1 the light pattern is illustrated as being created by interference pattern of three laser beams 3, 5 and 7. It will be appreciated that in this arrangement, in which the angles between the light beams are determined by mirrors and not by diffraction from a grating, the beams need to be coherent or partially coherent and conveniently this can be achieved by beam splitting from a single laser source. This allows easy control of the overall intensity, e.g. by positioning crossed-polarizers before the beam splitter, and the intensity, polarization and angle of incidence of each beam is also adjustable using standard optical elements. As shown in Figure 1 the beams come together in the body of photosensitive material to create in the material an interference pattern, which consists of a pattern of spatially varying intensity, in region 9. Thus the exposure (or radiation dosage) of the material in this region varies spatially.

The use of three beams creates an interference pattern which varies in two orthogonal directions within the material, but not in the third orthogonal direction. Thus regions of constant exposure can be made to extend linearly through the depth of the material in a direction which connects one side to the other. Usually this

direction will be perpendicular to the plane of the film, but it may also be slanted with respect to the perpendicular, should this be advantageous.

After sufficient exposure the exposed photosensitive material is treated, for instance by chemical development, to selectively remove regions of the material in dependence upon their exposure. Where, as explained below, the photosensitive material is a resin which cross-links in response to a certain exposure to light, the chemical development consists of removing using a solvent those regions which have not received a sufficient exposure to cross-link sufficiently (i.e. corresponding to the dark regions in the interference pattern). Although the intensity in an interference pattern varies smoothly, the response of the photosensitive material is non-linear so, the division between those parts of the material which have received a sufficient dose, and those which have not, is sharper than the variation in intensity of the interference pattern. Thus the effect of chemical development is to produce clearly defined voids in the material.

The necessary dosage of radiation can be applied either in a single exposure or in more than one exposure. The use of multiple exposure can increase the variety of structures which can be produced because the structure will correspond to a combination of different interference patterns, rather than to a single interference pattern.

Of course the region 9 in which interference occurs will generally be only a part of the prepared body of material 1. After chemical development this region may be cut-out and used. Alternatively the surrounding region can be uniformly exposed (or not) to create an integral support for the porous region.

The photosensitive material may be one which possesses an average number of crosslinkable groups per molecule of at least 3.0 with an equivalent weight per crosslinkable group of at most 1000. It has been found that with high functionality the network of crosslinks formed is potentially very dense giving high solubility contrast between strongly and weakly exposed material.

In general the photosensitive materials used in this invention are those possessing an average number of crosslinkable groups per molecule of at least 4, preferably at least 6 and especially about 8. They have an equivalent weight per

crosslinkable group (XEW) in general at most 500, typically at most 400, preferably at most 300, especially at most 230. Suitable photosensitive materials which can be used include epoxy resins ie. epoxy groups act as the crosslinkable groups.

It has been found that it is particularly advantageous to use the glycidyl ether of bisphenol A novolac which is available as EPON-SU-8 from Shell Chemicals. This resin has low intrinsic absorption at the laser wavelength ($\lambda = 355$ nm) and is capable of sub 0.1 micron resolution. It has an average of 8 epoxy groups per molecule. The material is therefore mostly in the form of a tetramer although other oligomers will usually be present. Its XEW is generally about 215, with a typical range from 190 to 230. It may be desirable to co-polymerise this material with a less crosslinkable plasticising epoxy monomer e.g. one with a single epoxy group in order to minimise shrinkage and/or film distortion on heating of the material (thereby reducing the functionality somewhat). Alternatively, the resin can be modified by using a so-called "expanding" monomer such as a spiro-orthocarbonate. Alternatively, improved physical properties of the polymer can be obtained by the addition of a binding agent such as a linear polymer. Effectively, any polymer can be used provided that it has sufficiently high functionality and the precursors have a low degree of optical absorption at the laser wavelength within a film typically 10-100 microns thick.

In one preferred embodiment of the present invention the photosensitive material is subjected to irradiation in the presence of a photo acid generator. Subsequent to exposure the material is heated to cure the crosslinked material.

Suitable photoacid generators which can be used, especially with epoxy resins, include onium salts such as triaryl sulfonium salts including triphenyl sulfonium antimony chloride which is available as Cyracure UV1 from Union Carbide. This particular generator is well suited to irradiation at 355 nm where it has sufficient absorption (molar extinction coefficient ~ 300 mol^{-1} dm^3 cm^{-1}). In general the molar extinction coefficient of the PAG should be from 50 - 2000 $mol^{-1}dm^3cm^{-1}$ at the laser wavelength. If the molecular coefficient is too large, the requirement for the sample to be optically thin means that the concentration of initiators is too small to effect polymerisation. On the other hand if it is too small, the PAG concentration

is so high that it adversely affect the properties of the polymer. By "optically thin" is meant that at the concentration at which it is used the PAG does not absorb more than 5% of the radiation which is incident upon it. In addition the quantum efficiency of the PAG should be sufficient for the exposure to cause insolubilisation of the photosensitive material. The effective quantum efficiency will be enhanced if the system involves chemical amplification. Obviously sufficient photosensitive material must be insolubilised to provide a volume of insolubilised material which is useful for practical purposes i.e. a useful volume, for example 1 mm^3 e.g. a film of size 5 x 5 x 0.04 mm. By "cause insolubilisation" is meant that there is sufficient proton generation for subsequent acid catalysed polymerisation, as discussed below, to result in a crosslinked material which is insoluble in a solvent which dissolves the unirradiated or weakly irradiated material. One of skill in the art will, of course, be able to select an appropriate PAG from those possessing the required molar extinction coefficients and optical thinness. For SU-8 a quantum efficiency of about 0.2 is needed for proton generation in the PAG. It is believed that the insolubility threshold is reached when each absorbed photon leads to the conversion of material equivalent to about 250 or 500 crosslinkable groups, for example about 600 epoxy groups, into insoluble polymer.

A specific example of the materials and process used to produce a filter element (actually the one shown in Figures 4 and 5) will now be described.

The photosensitive material was prepared by dissolving Epon-SU8 resin (Shell Chemicals), the glycidyl ether of bisphenol-A novolac, in γ-butyrolactone (50-60% wt. solids) with gentle heating (~30-40°C) and manual stirring. The resulting viscous solution was filtered to exclude particles larger than 1μm. Between 0.5% wt. and 3% wt. of a photoacid generator (PAG), a triaryl sulfonium salt (Cyracure UVI from Union Carbide) was added to the solution. The amount of PAG added determines the sensitivity of the photoresist, with 1.2% giving good results for these experimental conditions. The resulting photoresist was mixed thoroughly (and can be stored in the dark and away from heat sources until required).

Solid films of the photoresist (2-30 μm for the 50% wt. resist and 10-60 μm for the 60% wt. resist) were prepared by spinning the resist onto fused silica disks

(~2 cm diameter). For example to prepare a ~30 μm film, approx. 2 ml of the photoresist is pipetted onto the disk so that it is flooded. The film is then spun at 1000 rpm (5s ramp up, 40s hold, 5s ramp down) and then undergoes a post application bake (PAB) at 50°C for 5 mins followed by 15 mins at 90-100°C to evaporate the solvent. The interval between film preparation and exposure is kept as short as possible and generally less than 30 mins. Films can also be prepared by spreading, moulding or pouring.

The film was then exposed to an interference pattern created at the intersection of three beams from a frequency-tripled, injection seeded, Q-switched Nd:Yag laser (wavelength λ=355 nm). Such a pattern has two dimensional periodic translational symmetry.

The propagation directions, polarisation directions and relative intensities used are defined as follows:-

Normalised optical wave-vectors (relative to the conventional fcc unit cell axes):

(1)	-0.96225038	-0.19245008	-0.19245008
(2)	-0.19245008	-0.96225038	-0.19245008
(3)	-0.19245008	-0.19245008	-0.96225038

Polarisation unit vectors (in the same frame):

(1)	0.269517	-0.575382	-0.772202
(2)	0.804841	-0.0425761	-0.591961
(3)	0.933817	-0.337270	-0.119310

Relative intensities (I_1:I_2:I_3); (1:1:1)

These polarizations and relative intensities create essentially triangular channels (though with rounded corners). Varying the polarizations and relative intensities can create circular or elliptical channels, or other shapes as desired.

For instance circular channels as shown in Figure 6 can be created by using the following polarisation vectors:-

(1)	0.0000000	-0.7071068	0.7071068
(2)	0.7071068	0.0000000	-0.7071068
(3)	-0.7071068	0.7071068	0.0000000

The films were exposed in a single pulse (6 ns) of the laser. The total dose can be varied from 80-200mJcm^{-2} depending on the required polymer/air ratio in the filter. (The filling factor is also related to the time and temperature of the post exposure bake). The glass substrate was index matched to a thick glass block using mineral oil in order to reduce back reflections.

The beam geometries described above are those required to define the appropriate interference pattern in air. In practice refraction occurs as the beam enters the film of resist but it is possible to compensate for the refraction by changing the angle of the beams. This can be done, for example, by adding a shaped transparent optical element or elements with refractive index greater than unity into the beam paths, and may include the use of high index liquid between rigid optical elements.

The pulse duration is not critical. With an injection seeded laser the coherence length is equal to the pulse length, but this requirement can be relaxed if the optical path-lengths are made accurately equal. A cheaper but less effective option for increasing the coherence length is etalon-narrowing. In practice it is only necessary to achieve a coherence length of ~1cm. An ordinary un-narrowed Q-Switched Nd-YAG laser can approach this requirement. More importantly though injection-seeding makes the pulse energies, following third harmonic generation, far more reproducible, so that the control of the dose in a single pulse exposure becomes straightforward. A further advantage of single pulse operation is the absence of significant refractive index changes, that could perturb the interference, during the exposure.

Alternative light sources can be used, providing the photoinitiator is chosen to match the operating wavelength. An optical parametric oscillator or alternative laser which is continuously tunable, could therefore be used to construct filters with different spacings of pores, with or without a change in the angles between the interfering beams.

The exposure of the resist results in the production of a proton from the photochemically induced fragmentation of the PAG molecule. Acid catalysed polymerisation of the SU8 resin occurs in a post exposure bake (PEB). The glass

substrate was placed directly on a level hotplate at 40-120°C for between 1-20 mins depending upon the exposure dose, % PAG in the resist and the required filling factor. An PEB temperature below the melting point of the SU8 resin (80-90°C) results in a much "cleaner" lattice than one produced with a PEB above the resin's melting point.

The film was then developed in propyl glycol methyl ether acetate (PGMEA) in an ultrasonic bath to dissolve away the uncrosslinked resin. During development the film becomes detached from the substrate. The ultrasonic power was damped or attenuated to ~7 W to avoid mechanical damage to the film as it releases from the substrate. The bath was thermostated at 40-50°C and a typical development time is 40 mins for a 30 μm film. After the bath development, the film was washed with fresh PGMEA and finally rinsed in isopropyl alcohol before drying in air.

The resulting porous element is illustrated schematically in Figure 2. The body of photosensitive material 1 has an array of parallel channels 13 extending from one side to the other. A scanning electron micrograph of the actual filter element produced by the above method is shown in Figure 4. It is shown at higher magnification and fractured in Figure 5, where the channels 13 can easily be seen. It will be noted that the array is very regular, and that the channels are extremely narrow compared to their length.

The above example creates uniform channels through the filter. It is possible though, to vary the shape of the channels with depth. A schematic illustration of such a filter element is shown in Figure 3. It can be seen that the channels have a narrow section 15 at one end, which communicates with a wider section 17. If this is used to filter material passing from top to bottom in the orientation illustrated in Figure 3, it is a "non-blocking" filter. This can be produced in several ways. For instance, the photosensitive material 1 can have two layers of differing compositions. The top layer, which will form the narrowed part of the channel, has more PAG than the lower layer, so more cross-linking occurs on exposure, thus resulting in narrowed holes.

Alternatively a different intensity of illumination can be created in the region desired to have narrow holes, for instance a greater intensity there can be achieved by

uniformly exposing that surface with a shorter wavelength light which does not penetrate far into the photosensitive material, or with an evanescent wave whose field penetrates a short distance into the photosensitive material.

The filter element made using the techniques above can be supported for use on a porous substrate having larger pores than the filter to provide a non-blocking arrangement. The substrate can be made by the same technique, or by one of the standard techniques for making filters.

It will be appreciated that the invention is not limited to the materials described in the above example. For instance other epoxies or other photosensitive materials can be used, and as mentioned the process can be changed so that the degree of polymerisation/cross-linking in the material is higher in the regions of lower exposure to light, than it is in the regions of higher exposure to light. Thus both "negative" and "positive" processes are possible.

Further, although the above example uses a very fine interference pattern to create a very fine filter, the method is equally applicable to much larger scales, simply by producing an interference pattern of the desired scale.

The porous element made by the above method can be used directly as a filter element. Alternatively the technique can be used to make a mould from which a filter element of another material is created. For instance, an element produced using the materials above can have the voids filled with a ceramic such as titanium (IV) oxide and then be heated (e.g. to 575°C) to burn off the resin mould and sinter the ceramic. As an alternative to using a ceramic the voids in the resin can be filled with a material which is insoluble in a solvent for the resin. The resin can then simply be dissolved away. Of course, it is necessary either that the voids in the element are connected together so that the solidified filling will support itself when the resin is removed, or some other support must be provided for the solidified filling. It will be appreciated that the specific element produced by the method above and illustrated in Figure 4 would mould a disconnected array of upstanding "rods" which are not self-supporting. Connectivity can be achieved by varying the interference pattern so that the "rods" become connected (without losing porosity). Alternatively the "rods" could be formed on a substrate which supports them.

CLAIMS

1. A method of fabricating a porous filter element comprising the steps of: exposing a photosensitive material to an interference pattern of electromagnetic radiation, whereby the exposure through the material varies in accordance with the spatially varying intensity created by the interference; and treating the exposed photosensitive material to selectively remove regions of the material in dependence on the exposure to which that region was subject.

2. A method of fabricating a porous filter element according to claim 1, wherein the interference pattern is created by exposing the material to interfering beams of electromagnetic radiation.

3. A method according to claim 2 wherein at least one of the relative polarization, relative intensity, coherence and angles between the beams are selected in accordance with the desired pattern.

4. A method of fabricating a porous filter element according to claim 2 or 3, wherein the beams of electromagnetic radiation are laser beams.

5. A method of fabricating a porous filter element according to claim 4, wherein three non-coplanar laser beams are used to create the pattern, the three beams having equal intensities.

6. A method according to claim 5 wherein the beams have the following wave vectors and polarization unit vectors relative to conventional f.c.c. unit cells axes:

Normalised optical wave-vectors:

(1)	-0.96225038	-0.19245008	-0.19245008
(2)	-0.19245008	-0.96225038	-0.19245008
(3)	-0.19245008	-0.19245008	-0.96225038

Polarization unit vectors:

(A)	(1)	0.269517	-0.575382	-0.772202
	(2)	0.804841	-0.0425761	-0.591961
	(3)	0.933817	-0.337270	-0.119310
or (B)	(1)	0.0000000	-0.7071068	0.7071068
	(2)	0.7071068	0.0000000	-0.7071068
	(3)	-0.7071068	0.7071068	0.0000000

7. A method of fabricating a porous filter element according to any one of the preceding claims, wherein the regions extend in a straight line from a first side of said photosensitive material to a second, opposite side of said material.

8. A method of fabricating a porous filter element according to any one of the preceding claims, wherein the step of treating the exposed photosensitive material to selectively remove regions thereof comprises removing regions having an exposure below a predetermined level.

9. A method of fabricating a porous filter element according to any one of the preceding claims, wherein the step of treating the exposed photosensitive material to selectively remove regions thereof comprises removing regions having an exposure above a predetermined level.

10. A method of fabricating a porous filter element according to any one of the preceding claims, wherein the pattern is substantially non-varying through the depth of the material whereby said regions have a constant cross-section through the material.

11. A method of fabricating a porous filter element according to any one of claims1 to 9, wherein the pattern varies through the depth of the material to vary the cross-section of said regions through the depth of the material.

12. A method of fabricating a porous filter element according to claim 10 or 11, wherein the pattern repeats across the material perpendicular to the depth direction to create in the material a regular array of identical regions which extend through the depth of the material.

13. A method of fabricating a porous filter element according to any one of the preceding claims, wherein the material is a mixture of an epoxy resin and a photoacid generator.

14. A method of fabricating a porous filter element according to any one of the preceding claims, wherein the material to be exposed is in the form of a thin film.

15. A method of fabricating a porous filter element according to any one of the preceding claims wherein the photosensitive material comprises a plurality of regions of different composition such that the different regions react differently to exposure followed by treatment.

16. A method of fabricating a porous filter element according to claim 15 wherein the regions are layers, one on top of the other.

17. A method of fabricating a porous filter element according to any one of the preceding claims, comprising the further step of using said treated material as a lost mould to form a porous filter element.

18. A method of fabricating a porous filter element according to claim 17, wherein the voids left by said selective removal are at least partly filled with a material from which the filter element is to be formed, and then the exposed and treated photosensitive material is removed.

19. A method of fabricating a porous filter element according to claim 18,

wherein the voids are filled with a ceramic which after introduction into the voids is sintered, said sintering burning off the exposed and treated photosensitive material to leave the ceramic porous.

20. A method according to any one of the preceding claims wherein the exposure time and/or intensity of the e.m. radiation is set selectively in accordance with the desired size of the regions.

21. A porous filter element made by the method of any one of the preceding claims.

Fig.1.

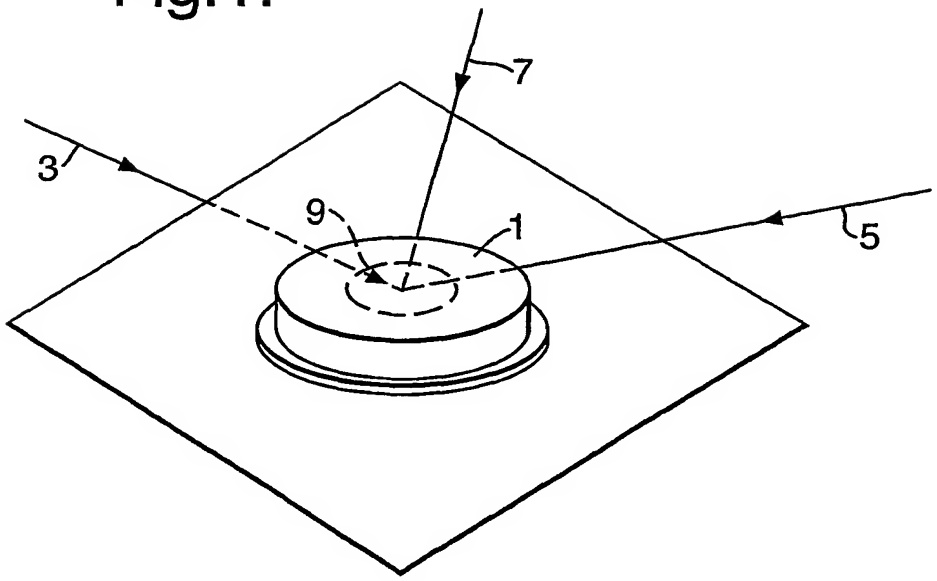


Fig.2.

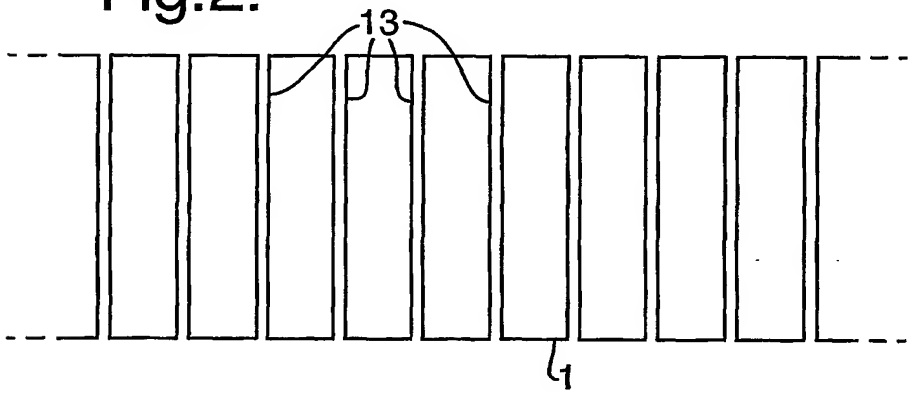


Fig.3.

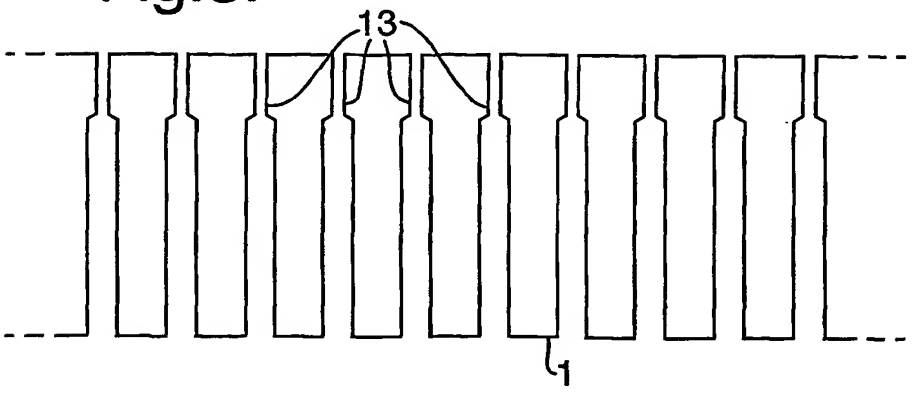


Fig.4.

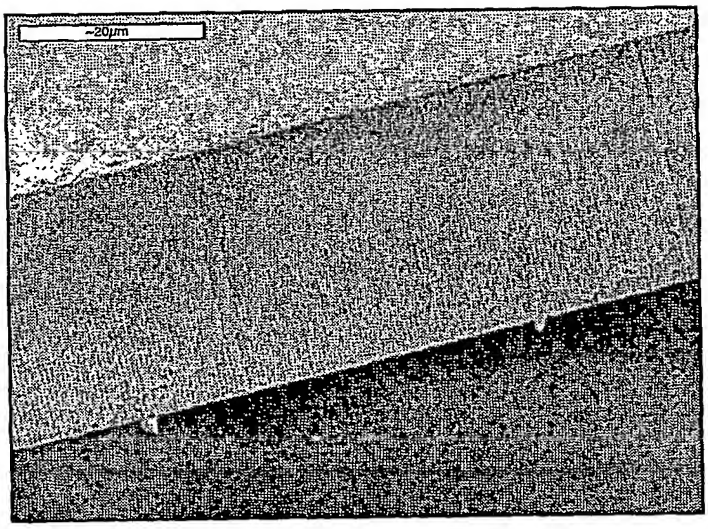


Fig.5.

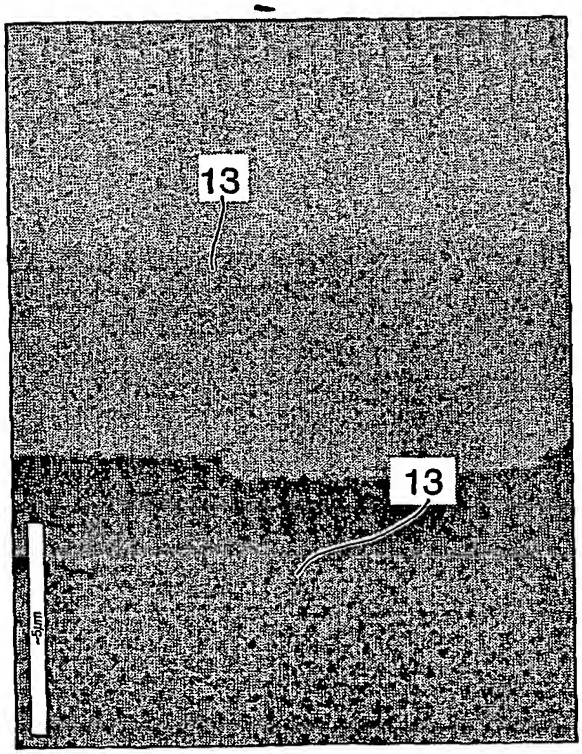
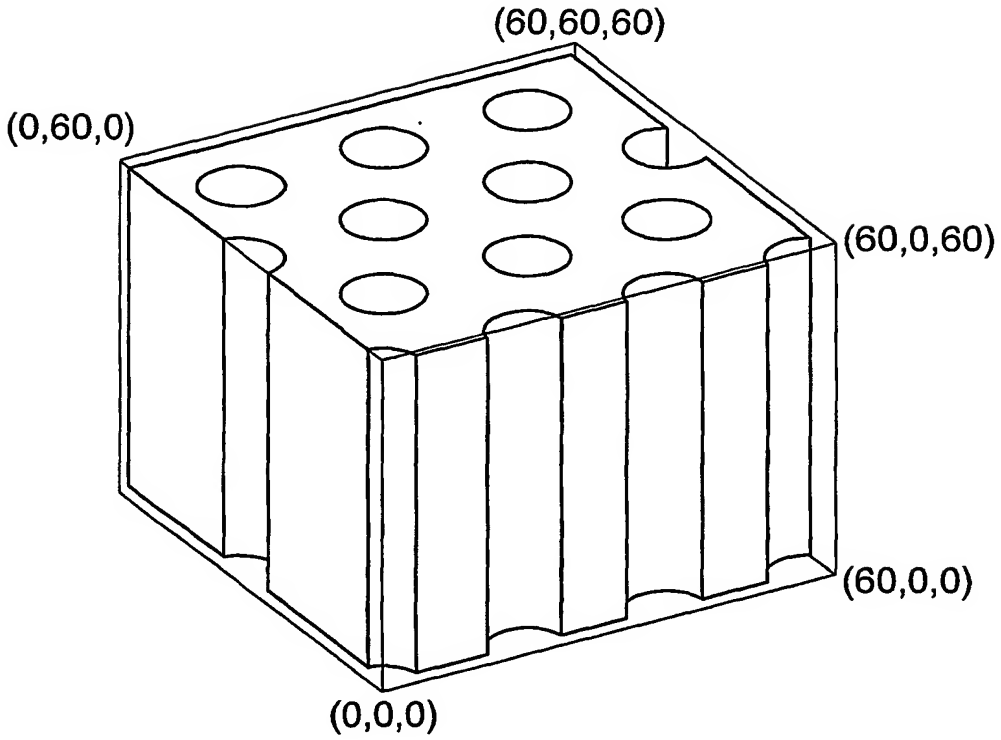


Fig.6.



INTERNATIONAL SEARCH REPORT

In [redacted]nal Application No
PCT/GB 00/03602

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D39/16 B01D67/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B01D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
WPI Data, PAJ, EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 801 379 A (C.EHRSAM ET AL.) 31 January 1989 (1989-01-31) the whole document	1-5
A	US 4 652 412 A (C.A.CHIULLI) 24 March 1987 (1987-03-24) column 3, line 4 - line 31; claim 1; figure 1	1
A	US 4 923 608 A (T.FLOTTMANN ET AL.) 8 May 1990 (1990-05-08) the whole document	1-21
A	US 5 256 360 A (H.LI) 26 October 1993 (1993-10-26) claim 1	1

[ ] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 February 2001	20/02/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Bertram, H

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

In[illegible]al Application No
PCT/GB 00/03602

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4801379 A	31-01-1989	CH 671709 A	29-09-1989
		AT 73687 T	15-04-1992
		DE 3777480 A	23-04-1992
		DK 230187 A	24-01-1988
		EP 0254103 A	27-01-1988
		FI 871954 A	24-01-1988
		JP 63031516 A	10-02-1988
		NO 872990 A	25-01-1988
US 4652412 A	24-03-1987	NONE	
US 4923608 A	08-05-1990	DE 3742770 A	29-06-1989
		DE 3887121 D	24-02-1994
		EP 0325752 A	02-08-1989
		JP 2043927 A	14-02-1990
US 5256360 A	26-10-1993	NONE	